TITLE OF THE INVENTION

Fuel Injection Valve and Internal Combustion Engine Mounting the Same

BACKGROUND OF THE INVENTION

The present invention relates to a fuel injection valve which injects fuel into an internal combustion engine and concerns to a technology for forming fuel spray excellent in its atomization.

CONVENTIONAL ART

JP-A-10-43640 (1998), in particular page 2 and Figs.1 and 2,discloses one of conventional fuel injection valves in which a valve body being provided with a valve seat at an inner wall face forming a fluid passage , a valve member for opening and closing the fluid passage by being unseated a contacting portion thereof from the valve seat and by being seated the same on the valve seat and an orifice plate attached to the valve body at the fluid downstream side from the valve member and having an orifice penetrating the orifice plate in its thickness direction, wherein the opposing face of the orifice plate to the valve member ,the top end face of the valve member and the inner wall face of the valve body form a substantially disk shaped fluid chamber and in which an obstacle is provided for disturbing the fluid flowing from an opening between the contacting portion and the valve seat to the orifice.

The above patent document discloses as the obstacle of disturbing the fluid flow a provision of unevenness which is

provided either on the top end face of the valve member at the fluid flow downstream side from the opening portion between the contacting portion and the valve seat or on the face of the orifice plate opposing to the valve member.

In the above conventional art, before the fuel reaches to the injection hole , the disturbance is caused to make small the particle diameter of the spray. However, in order to reduce fuel consumption effectively or to reduce exhaust amount of unburned gas components (HC,CO) of the fuel, further atomization of the spray is required.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a fuel injection valve which permits an improvement in atomization performance and to provide an internal combustion engine which realizes reduction in the fuel consumption amount and reduction in the exhaust amount of unburned gas components (HC,CO) of the fuel with the atomization improved fuel spray.

In order to achieve the above object, the present invention introduced a variety of grooves including an annular groove near an injection hole, thereby through flow contracting effect on the fuel flow overflowed the groove in the injection hole, the velocity of the injection flow is increased and the atomization performance is enhanced.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a vertical cross sectional view of a fuel injection valve representing an embodiment of the present invention;

Fig.2 is a vertical cross sectional view of a nozzle portion in an embodiment according to the fuel injection valve of the present invention;

Fig.3 is a plane view of a plate member seen from an injection hole inlet side in the embodiment according to the fuel injection valve of the present invention;

Fig.4 is a plane view of a plate member seen from an injection valve inlet hole in a modified embodiment according to the fuel injection valve of the present invention;

Fig.5 is a view illustrating a manner of an overflow around an annular groove provided near the injection hole inlet portion in the embodiment according to the fuel injection valve of the present invention;

Fig.6 is a view illustrating a manner of velocity acceleration due to the overflow and atomization promotion due to eddy current in the present invention;

Fig.7 is a view illustrating a flow velocity distribution at the injection hole outlet portion in the embodiment according to the fuel injection valve of the present invention;

Figs.8(A) through 8(D) are views of a variety of groove configurations in the embodiments according to the fuel injection valve of the present invention;

Fig.9 is a vertical cross sectional view of a nozzle portion of an embodiment, in which upstream of the plate member is structured into a radial flow type, according to the fuel injection valve of the present invention;

Fig.10 is a vertical cross sectional view of a nozzle

portion of an embodiment, in which upstream of the plate member is structured into a collision flow type, according to the fuel injection valve of the present invention;

Fig.11 is a vertical cross sectional view of a nozzle portion of an embodiment, in which upstream of the plate member is structured into a flat valve type, according to the fuel injection valve of the present invention;

Fig.12 is a partial cross sectional view of an embodiment in which a fuel injection valve of the present invention is mounted on an internal combustion engine;

Fig.13 is a vertical cross sectional view of a nozzle portion in an embodiment of a fuel injection valve with a single injection hole according to the present invention; and,

Fig.14 is a partial cross sectional view of an embodiment in which a direct injection type fuel injection valve according to the present invention is mounted on an internal combustion engine.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Hereinbelow preferred embodiments of the present invention will be explained with reference to Fig.1 through Fig.14. In the following explanation a plane including an axial line of a valve body and in parallel therewith is called as vertical cross sectional plane.

Fig.1 is a vertical cross sectional view showing a structure of a normally closed and solenoid type fuel injection valve, one of fuel injection valve types, representing an embodiment of the present invention. (Although advantages of the

present embodiment are not limited to the solenoid type fuel injection valve.)

The fuel injection valve as shown in Fig.1 is provided with a yoke 105 of a magnetic substance surrounding a solenoid coil 109, a core 106 which locates at the center of the solenoid coil 109 and one end of which is contacted to the core 106, a valve body 102 which is lifted by a predetermined amount, when the solenoid coil 109 is excited, a seat face 110 facing the valve body 102, a fuel injection chamber 101 which injects fuel being flowed through a gap between the valve body 102 and the seat face 110,and a plate member 111 having a plurality of injection holes 107 under the fuel injection chamber 101.

At the center of the core 106, a spring 108 is provided as an elastic member which works to press the valve body 102 onto the seat face 110. When no current is fed to the coil 109, the valve body 102 is closely contacted. Fuel is supplied from a fuel supply port under pressurized state by a fuel pump not shown. And a fuel passage in the fuel injection valve up to the closely contacted position of the seat face 110 with the valve body 102. When a current is supplied to the coil 109 and the valve body 102 displaces due to the magnetic force induced and separates from the seat face 110, the fuel is concentrated around the axial center in the fuel injection chamber 101, thereafter, the fuel flows along the plate member 111 radially in the outer circumferential direction and is injected through the plurality of fuel injection holes 107 toward such as an intake port of the engine.

Fig.2 is a vertical cross sectional view of the nozzle portion. A feature of the present embodiment is that grooves 201 are formed between the respective injection holes 107 on the face of the plate member 111 in the fuel injection passage and along the circumferential direction of the respective injection holes 107 as shown in Fig.3. Since the grooves are provided between the respective injection holes 107, the respective grooves are naturally formed near the respective injection holes 107. Further, the grooves 201 other than the annular grooves as shown in Fig.3 can be used. For example, Fig.4 shows a modification in which instead of the continuous annular grooves four rectangular shaped grooves 401 are provided in the circumference of the respective injection holes. Each of the grooves 401 is configured in such a manner that when assuming the length of the rectangular groove 401 in circumferential direction of the injection hole as d and the length thereof in radial direction of the injection hole as t, a ratio d/t is selected to be more than 1 in that d>t, reason of which is that in order to induce the overflow effect due to the grooves more efficiently, it is preferable that the circumferential length d is longer than the radial direction length t, therefore, the most preferable configuration is the circumferential grooves. Further, in Fig.4 modification although four pieces of rectangular grooves 401 are provided for each of the injection holes, the number thereof is not limited thereto under the allowable physical space therein.

Still further, as shown in Fig.3 a flat portion (plane

portion) 203 is formed between the adjacent injection holes 107 at the outside of the grooves 107.A distance (interval) L between the adjacent injection holes 107 at the outside the grooves 201 on the flat portion 203 is determined longer than a distance (interval) l between the inner edge of the groove 201 and the outer edge of the injection hole 107. In other words, the groove 201 is disposed close to the injection hole 107 in such a manner that the distance I is shorter than the distance L. Further, the flat portion (plane portion) 203 contributes to enhance the overflow inducing effect, which will be explained later.

The function and advantages of the present embodiment will be explained with reference to Figs.5 through 7. Because of the shaping of the grooves as explained above, as shown in Fig.5, fuel 501 which comes from the outer circumferential direction flows deep into the groove, forms overflows 502 and flows into the respective injection holes 107. Thereafter, as shown in Fig.6 because of the effect of the flows forming the overflows 502, fuel flow 601 forms a contracted flow portion 602 of which diameter is slightly smaller than that of the injection hole 107 and injected from the injection hole 107. Fig.7 shows a flow velocity distribution at the injection hole outlet portion. As will be seen from Fig.7, with the provision of the grooves 201, since the overflow 502 and the contracted flow portion 602 are formed, the maximum flow velocity in the flow velocity distribution 702 at the injection hole outlet portion is increased in comparison with that in a flow velocity distribution

701 in the case of no provision of the grooves 201. Because of this acceleration effect, turbulence of gas and liquid interface between fuel and air is enhanced, and many number of vortexes 603 are formed which reduces the diameter of spray particles 605

Figs.8(A) through 8(D) show configurations of the grooves 201 formed around the injection hole 107. Fig.8(A) shows an instance wherein a rectangular groove 201A is formed, Fig.8B shows another instance wherein a V shaped groove 201B is formed, Fig.8(C) shows still another instance wherein a groove 201C is formed of which inner side wall inclination angle near the injection hole is designed steeper than that remote from the injection hole, and Fig.8(D) shows a further instance wherein a groove 201D is formed in which the top level of a projection 204 around the injection hole 107 is formed higher by a height H than that of the surface of the plate member 203 at the upstream side of the groove. The groove configurations as shown in Figs.(8A) through 8(D) can basically form the overflows 502. Further, with regard to the grooves as shown in Figs.8(B) and 8(C) the bottom shape need not be an acute angle, but can be rounded. Still further, with regard to the groove as shown in Fig.(8D) the height H is preferable to be smaller than the diameter ϕ D of the injection hole 107 to form the overflows.

As has been explained above, with the fuel injection valve of the present embodiment, the overflows 502 are formed at the position where the grooves 201 are disposed, and further through the formation of the contracted flows 602 in the fuel injection holes 107, the maximum flow velocity at the fuel

injection outlet portion is increased, thereby, the turbulence of the gas and liquid interface between fuel and air is enhanced, and the atomization performance is improved.

Figs.9 through 11 show vertical cross sectional views of nozzle portions in respective embodiments wherein the structures upstream the plate member 111 of the fuel injection valve according to the present invention are formed respectively in a radial floe type, a collision flow type and a flat valve type.

In the radial flow type as shown in Fig.9, a fuel contraction portion 901 which once contracts the fuel flowing through the gap between the valve body 102 and the seat face 110 is provided, under the fuel contraction portion 901 a fuel outwardly radiating chamber 902 which forces to flow the fuel toward the outer circumference is provided, and further, under the fuel outwardly radiating chamber 902 a plate member 111 having a plurality of injection holes is provided.

In the collision flow type as shown in Fig.10, the fuel injected outwardly through the respective injection holes 107 on the plate member 111 is collided each other at a collision point 1001 to divide the spraying direction into two directions.

In the flat valve type as shown in Fig.11, instead of the ball valve type as shown in Fig.2 and 10, the valve body 1101 is formed in a flat type, and further, a seat face 1102 through which fuel supply is controlled by the vertical movement of the valve body 1101 is disposed between the valve body 1101 and the plate member 111.

Any types of the above radiation flow type, collision flow type and flat valve type fuel injection valves can achieve the same or further atomization performance in comparison with the fuel injection valve as shown in Fig.2.

Fig.12 shows an example in which the fuel injection valve 1201 according to the present invention as shown in Fig.1 is mounted on an internal combustion engine. Since as the fuel injection valve a like solenoid type fuel injection valve as shown in the above embodiment is used, an explanation of the constitutional elements is omitted. The internal combustion engine as shown in Fig.12 is constituted by a cylinder head 1202, an intake valve 1203, an ignition plug 1204 which ignites the mixture gas of fuel and air, a piston 1205, a cylinder 1206, an exhaust valve 1207, an intake port 1208 which introduces air in to the cylinder 1206 and an exhaust port 1209 which exhausts the combustion gas from the cylinder. Further the fuel injection valve is provided with a connector through which a current for driving the injection valve is supplied.

Further, in Fig.12 the intake valve 1203 is shown in closed state. However, actually when the fuel is injected in spray from the fuel injection valve 1201 to the combustion chamber 1211, the intake vale 1203 is opened. Herein, the fuel injection start timing of the fuel injection valve 1201 may one either when the intake valve is actually opened or before the intake valve 1203 actually starts valve opening in view of the fuel flying time. In such instance, the flying time is set in such a manner that the fuel injected at the injection start reaches to the intake

valve at the timing when the intake valve 1203 is actually opened. Further, within an allowable range, the fuel injection start timing can be set so that the fuel injected at the injection start reaches the intake valve 1203 at the timing before the intake valve 1203 starts actual valve opening.

In the above embodiments, the fuel injection valves in which a plurality of injection holes 107 are provided on the plate member 111,however the present invention is not limited to such embodiments, in that as shown in Fig.13, for the fuel injection valve having a single injection hole 107 on the plate member 111 a groove which runs along the circumferential direction of the injection hole 107 can be provided.

Fig.14 shows a partial cross sectional view of a further embodiment in which a direct injection type fuel injection valve 1401 including the single injection hole 107 on the plate member 111 as shown above and injecting fuel directly into the combustion chamber 1211 is mounted on the internal combustion engine. The direct injection type fuel injection valve 1401 is directly on the cylinder 1206 near the intake valve 1203 and fuel spray 1402 is directly injected in to the combustion chamber 1211.

In the above embodiments, the solenoid type fuel injection valves have been explained, however, the present invention is not limited to such embodiments, and the present invention can be generally applied to fuel injection valves other than the solenoid type within the range where the substantially the same function and advantages as the present embodiments can be obtained.

According to the above respective embodiments, a measure for atomizing fuel is provided near the injection valve, an effective fuel atomization can be achieved.

Therefore, the internal combustion engine according to the embodiments being provided with the fuel injection valve of the present invention, since the atomization performance of the fuel spray injected from the fuel injection valve is excellent, the exhaust amount of unburned components (HC,CO) can be reduced.

According to the present invention, through the formation of the overflows at the positions where the grooves are located and further through the formation of the contracted flow portion in the injection holes, and with the advantage of increasing the maximum flow velocity of the spray at the injection hole outlet portion, turbulence of gas and liquid interface between fuel and air is accelerated and the atomization performance is improved. Thereby, in the internal combustion engine using the same, since the atomization performance of the fuel spray injected from the fuel injection valve is excellent, the exhaust amount of unburned components (HC,CO) can be reduced.